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DIVISION 15 - MECHANICAL

SECTION 15132

SUBMERSIBLE PUMP, MIXED-FLOW TYPE

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SECTION 15132

SUBMERSIBLE PUMP, MIXED-FLOW TYPE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S2.19	(1999) Mechanical Vibration - Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Residual Unbalance, Including Marine Applications (Note: was ASA86, but that document refers to ANSI S2.19.)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C200	(2005) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C203	(2002; A C203a-99) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C207	(2007) Standard for Steel Pipe Flanges for Waterworks Service-Sizes 100 mm through 3600 mm 4 in. through 144 in.
AWWA C208	(2001; R 2002) Standard for Dimensions for Fabricated Steel Water Pipe Fittings

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2006; Errata 2006) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B46.1	(2002) Surface Texture (Surface Roughness, Waviness and Lay)

ASTM INTERNATIONAL (ASTM)

ASTM A 108	(2007) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A 167	(1999; R 2004) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 176	(1999; R 2004) Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip
ASTM A 242/A 242M	(2004e1) Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A 27/A 27M	(2003) Steel Castings, Carbon, for General Application
ASTM A 276	(2004) Stainless Steel Bars and Shapes
ASTM A 297/A 297M	(1997; R 2003) Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application
ASTM A 312/A 312M	(2004b) Seamless and Welded Austenitic Stainless Steel Pipes
ASTM A 36	(1992) Structural Steel
ASTM A 36/A 36M	(2004) Carbon Structural Steel
ASTM A 48/A 48M	(2003) Gray Iron Castings
ASTM A 516/A 516M	(2004) Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 576	(1990b; R 2000) Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM A 668/A 668M	(2004) Steel Forgings, Carbon and Alloy, for General Industrial Use
ASTM B 148	(1997; R 2003) Aluminum-Bronze Sand Castings
ASTM B 584	(2004) Copper Alloy Sand Castings for General Applications
ASTM D 2000	(2003ae1) Rubber Products in Automotive Applications

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.4	(2000) Centrifugal Pumps
HI 2.1-2.4	(2000) Vertical Pumps

HI 2.6	(2000) Vertical Pump Tests
HI 9.1-9.5	(2000) Pumps - General Guidelines for Types, Applications, Definitions, Sound Measurements and Documentation
HI 9.6.4	(2000) Centrifugal and Vertical Pumps, Vibration Measurements and Allowable Values

ISA - THE INSTRUMENTATION, SYSTEMS AND AUTOMATION SOCIETY (ISA)

ISA RP2.1	(1978) Manometer Tables

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2007) Standard for Motors and Generators
NEMA WC 7	(1988; Rev 3 1996) Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2007) National Electrical Code - 2008 Edition

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Submersible Pump; G, DT

Within 90 days of Notice of Award, submit drawings listed below. Submitted drawings shall be of sufficient size to be easily read. Submit information in the English language. Dimensions shall be in metric with English conversion.

a. Outline drawings of the pump showing dimensions and weight of the pump/motor.

b. Drawings showing details and dimensions of pump mounting design and layout including any embedded items.

c. Cross-sectional drawings of the pump, showing each component, should show major or complicated sections of the pump in detail. On each drawing indicate an itemized list of components showing type, grade, class of material used, and make and model of the standard component used. Include detail and assembly drawings of entire pumping unit assembly.

d. Provide drawings covering the installation that the

Contractor intends to furnish to the erecting engineer.

e. The capacity-head curve should indicate efficiency, bhp, and NPSHR.

f. Motor characteristic curves or tabulated data (test or calculated) should indicate the speed, power factor, efficiency, current, and kilowatt input, all plotted or tabulated against percent load as abscissas.

SD-03 Product Data

Materials

Submit a list designating materials to be used for each pump part along with the submittal of the drawings.

If deviation from specified materials is desired, submit complete specifications for the proposed deviating materials after award of the contract.

Equipment; G, DT

Within 60 days of Notice of Award, submit a list of equipment as specified in paragraph Equipment.

Spare Parts

Submit 10 copies of manufacturers complete parts list showing all parts, spare parts, and bulletins for pump. Clearly show all details, parts, and adequately describe parts or have proper identification marks. The parts lists shall be printed on good quality 8 1/2 by 11 inch paper, bound separately of the Operation and maintenance manual with a flexible, durable cover. Drawings incorporated in the parts lists may be reduced to page size provided they are clear and legible, or they may be folded into the bound lists to page size. Photographs or catalog cuts of components may be included for identification.

Computations; G, DT

Submit sufficient hydraulic computations to substantiate pump selection and demonstrate that the selected pump can meet the project design and operating requirements as specified.

Installation Instruction Manual; G, DT

No later than 30 days prior to time of pump delivery, submit three copies of a typed and bound manual describing procedures to be followed by the installation engineer in assembling, installing, and dry- and/or wet-testing the pump. Coordinate and consolidate the description of the pump with similar descriptions for other specified pump parts. The description shall be of such a nature that it may be comprehended by an engineer or mechanic without extensive experience in erecting or installing pumps of this type. The description shall be a step-by-step explanation of operations required, and shall include, where applicable, such things as alignment procedures, bolt torque values, recommended instrument setups, recommended gauges and instruments, and similar

details.

Factory Test

Submit a description of the factory test setup and test procedure proposed. Submit data and drawings sufficient to demonstrate that testing is in compliance with HI 2.6.

Pump Field Tests; G, DT

Submit the field test plan prior to field testing.

SD-06 Test Reports

Factory Test Report; G, DT

Within 30 days of receipt of approval of the witnessed field test, submit nine bound copies of a report covering test setup and performance tests. The factory test report shall include the specified information.

Field Test Report; G, DT

Submit five (5) copies of the field test report.

Installation and Start-Up Engineer

Submit the installation report.

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions; G, DT

Submit 10 copies of the manual containing complete information on operation, lubrication, adjustment, routine and special maintenance disassembly, repair, reassembly, and trouble diagnostics of pump and auxiliary equipment. The operation and maintenance manual shall be printed on good quality 8 1/2 by 11 inch paper, bound separately from the parts list, and bound between a flexible, durable cover. Drawings incorporated in manual may be reduced to page size provided they are clear and legible, or they may be folded into the manual to page size. Photographs or catalog cuts of components may be included for identification.

1.3 SYSTEM DESCRIPTION AND PERFORMANCE REQUIREMENTS

1.3.1 General Project Requirements

Design, furnish, and install seven (7) identical pumping units for the Des Planine River Local Flood Protection Project Levee 37, Three Pumping Station s shown in the contract drawings on sheet M-01 thru M-03. Water pumped will not exceed 70°F, will be relatively turbid, and may contain sand, silt, and trash capable of passing the trashrack, having 1-5/8 inch clear openings.

1.3.2 Pumping Unit Description

In general, each pumping unit includes a pump/motor, discharge tube,

discharge elbow, air vent, lifting cable, and controls. Each pump shall be of the vertical, mixed-flow submersible type for storm water flood control attached to the same shaft with a submersible electric motor. The pump/motor shall be electrically operated and installed in a discharge tube. Except as otherwise stated or noted, the terms pump and pump/motor both refer to a pump/motor integral unit.

1.3.3 General Design Requirements

a. The pump shall meet head, capacity, speed, efficiency, pump sump design, range of operation, cavitation, and vibration requirements as specified.

b. The pump shall be designed for runaway speed as calculated by the Contractor for the system shown and specified. Waterhammer calculations shall be included when long discharge lines exist. The reverse speed shall be calculated assuming power failure and discharge valves fail to close.

c. The pump shall, as a minimum, meet the applicable design, materials, and manufacture requirements of HI 1.1-1.4, HI 2.1-2.4, HI 9.1-9.5 and these specifications.

d. The pumping unit design and performance shall have been demonstrated by previous successful operation of pumps of the required type and of equal design complexity by the manufacturer.

e. The pump shall operate in a discharge tube. The discharge tube shall fit within the dimensions shown so that installation and maintenance can be carried out by an mobile crane. The weight of the pump/motor integral unit shall not exceed 1000 lb.

f. The pump shall be designed for the calculated hydraulic pressure including waterhammer to which the pump parts are exposed.

g. The pump losses, as calculated by the Contractor, are in addition to the specified head and shall be allowed for when computing the pump system output.

h. The pump shall have a continuously rising head characteristic with decreasing capacity over the required range of operation specified. The pump shall not have an unstable operating characteristic over the required range of operation.

i. The pump shall meet all requirements for net positive suction head required (NPSHR) and operate without surging.

j. Associated pumping equipment including, but not limited to, electrical controls, instrumentation, and pump control center shall be suitable for outdoor operation.

1.3.4 Computations and Design of Discharge System

a. The pumping unit shall discharge into the discharge system shown. The system loss table is included as FIGURE 1 at the end of this section to permit determination of total head. The total operating head that is provided on the contract drawings. Losses within the pumping unit shall be determined by the Contractor. The pumping unit shall discharge into the discharge chamber shown. The total head

indicated on the pump schedule on the contract drawings sheet M-01 thru m-03 system includes all losses beyond the pumping unit. Losses within the pumping unit shall be determined by the Contractor.

The pumping unit shall discharge into the discharge system shown. The Contractor shall determine losses within the pumping unit.

1.3.5 Operating Conditions

a. The pump shall be capable of operating in the dry (for the purpose of maintenance and operating checks) for short periods of time as stated in the manufacturer's operating instruction.

b. The pump manufacturer shall establish and state in the operating manual the procedures for starting and stopping the pumps, including setting of valves or any sequential operations.

1.3.6 Performance Requirements

a. When operated in the dry, the maximum level of vibration of the assembled pumping unit shall not be greater than the value of the lower limit of the good range of the "General Machinery Vibration Severity Chart". This chart can be obtained from Entek IRD, 1700 Edison Drive, Cincinnati, Ohio 45150. Measurements shall be taken at pump operating speed during the Factory Test and the field start-up test.

b. The pump shall be capable of operating without instability over the required range of head.

1.3.7 Capacities

a. Discharge shall not be less than 2600 gpm against total design head 13.1 ft with water surface in the sump at elevation 629.75 ft. for Pump Station No. 1. Pump shall operate within 5 feet to 16 feet of total dynamic head.

b. Discharge shall not be less than 2600 gpm against total designed head 13.3 ft with water surface in the sump at elevation 630.0 ft. for Pump Station No. 2. Pump shall operate within 5 feet to 16 feet of total dynamic head.

c. Discharge shall not be less than 2600 gpm against total design head 13.3 ft, with water surface in the sump at elevation 631.5 ft. for Pump Station No. 3. Pump shall operate within 5 feet to 16 feet of total dynamic head.

1.3.8 Efficiency

The pump shall have an hydraulic efficiency of not less than 65 percent at design capacity as indicated in paragraph 1.4.7.

1.3.9 Equipment

The Contractor shall submit the names of the manufacturers, performance capacities, and other relevant information for the machinery and other equipment contemplated to be incorporated into the work.

1.4 PUMP SUPPLIER EXPERIENCE AND RESPONSIBILITY

The pumps shall be designed and manufactured by a firm that is regularly engaged in the manufacture of the type of pump described in these specifications. The pump manufacturer shall have overall responsibility to supply the pumping unit (submersible pump/motor, , discharge tube, discharge elbow, cables, instrumentation and accessories) that meet the requirements of this specification. Thus, during start-up, installation, and performance evaluation, the pump manufacturer is the sole responsible party. The pump manufacturer shall supply a list of installations at which pumps of his manufacture, and ones similar to those specified, have been operating for at least 2 years. The components and materials of the pumping unit may occur at different facilities, and be the product of other manufacturers.

1.5 SHIPPING AND STORAGE

The pump will be inspected for damage or other distress when received at the project site. The pump and associated equipment shall be stored indoors as recommended by the pump manufacturer, protected from construction or weather hazards at the project site. The pump and equipment shall have adequate short-term storage in a covered, dry, and ventilated location prior to installation. The manufacturer's instructions shall be followed for extended storage. Proper equipment for handling the pump shall be supplied and shall be considered as special tools if not completely standard.

1.6 SPECIAL TOOLS

Furnish one set of all special tools required to completely assemble, disassemble, or maintain the pumps. Special tools refers to oversized or specially dimensioned tools, special attachment or fixtures, or any similar items. Lifting devices required for use in conjunction with the truck crane shall be furnished.

1.7 INSTALLATION AND START-UP ENGINEER

The Contractor shall furnish a competent installation engineer fluent in the English language who is knowledgeable and experienced with the installation and start-up procedures for submersible pumps and the associated equipment specified. Installation/erecting engineers provided by this section shall include those from Contractor's suppliers. When so requested, the installation engineer shall be responsible for providing complete and correct direction during installation, initial starting, and subsequent operation of equipment until field tests are completed. The installation engineer shall initiate instructions for actions necessary for proper receipt, inspection, handling, uncrating, assembly, and testing of equipment. The installation engineer shall also keep a record of

measurements taken during erection and shall furnish one copy to the Contracting Officer on request or on the completion of the installation of assembly or part. The erecting engineer shall instruct the Contracting Officer or others as designated in the operation and maintenance features of the pump units.

PART 2 PRODUCTS

2.1 MATERIALS AND METALWORK FABRICATION

Materials and fabrication shall conform to the requirements provided herein and to Section 05055A METALWORK FABRICATION, MACHINE WORK, MISCELLANEOUS PROVISIONS and Section 05502A METALS: MISCELLANEOUS, STANDARD ARTICLES, SHOP FABRICATED ITEMS and to additional specified requirements. Classifications and grade of material incorporated in the work shall be in accordance with designated specifications. Deviations from the specified materials shall be submitted in accordance with paragraph SUBMITTALS. The materials of construction shall comply with the following:

TABLE 1 - MATERIALS OF CONSTRUCTION

PART	MATERIAL
Discharge Bowl	Cast iron, cast steel or steel plate
Suction Bell	Cast iron, cast steel or steel plate
Pump bowl	Cast iron, cast steel or steel plate
Impeller	Stainless steel or aluminum bronze
Shaft	Cold-rolled carbon steel or stainless steel
Wearing ring	Manufacturer's standard
Bolts, key, etc.	Stainless steel
O-rings	Nitrile rubber
Mechanical seals	Tungsten or Silicon carbide
Discharge tube	Steel plate
Discharge elbow	Steel plate

2.1.1 Designated Materials

Designated materials shall conform to the following specifications, grades, and classifications.

MATERIALS	SPECIFICATION, GRADE, CLASS
Aluminum-Bronze	ASTM B 148, Alloy No. C95500 Castings
Cast Iron	ASTM A 48/A 48M, Class Nos. 30A, 30B, and 30C
Cast Steel	ASTM A 27/A 27M Grade 65-35, annealed
Coal Tar Protective Coatings	AWWA C203
Cold-Rolled Steel Bars	ASTM A 108, min, Wt. Strm 65,000 psi
Copper Alloy Castings	ASTM B 584, Alloy No. C93700
Corrosion-Resistant Alloy Castings	ASTM A 297/A 297M, Grade CA-15, CAGNN and CF-8M

MATERIALS	SPECIFICATION, GRADE, CLASS
Dimensions for Steel Water Pipe Fittings	AWWA C208
Hot-Rolled Stainless	ASTM A 576, Graded G10200, G10450, and G11410
Ring Flanges	AWWA C207, Class B
Rubber Products in Automotive Applications	ASTM D 2000
Seamless and Welded Austenitic Stainless Steel Pipe	ASTM A 312/A 312M
Stainless Bars and Shapes	ASTM A 276, Grades S30400 and S41000
Steel Forging	ASTM A 668/A 668M, Class F
Steel Pipe 6 in. and Larger	AWWA C200
Steel Plates, Pressure Vessel	ASTM A 516/A 516M, Grade 55
Steel Plate	ASTM A 242/A 242M
Stainless Steel Plate	ASTM A 167, UNS S30400 or ASTM A 176, UNS S40500
Quality Steel	ASTM A 36/A 36M
Surface Texture	ASME B46.1

2.1.2 Bolted Connections

2.1.2.1 Bolts, Nuts, and Washers

Bolts, nuts, and washers shall conform to requirements herein specified and the paragraphs SUBMERSIBLE PUMP, DISCHARGE TUBE AND DISCHARGE ELBOW, and the subparagraph, NUTS AND BOLTS for types required. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to bolt axis.

2.1.2.2 Materials Not Specifically Described

Materials not specifically described shall conform to the latest ASTM specification or to other listed commercial specifications covering class or kinds of materials to be used.

2.1.3 Flame Cutting of Material

Flame cutting of material other than steel shall be subject to the approval of the Contracting Officer. Shearing shall be accurately done, and all portions of work neatly finished. Steel may be cut by mechanically guided or hand-guided torches, provided an accurate profile with a smooth surface free from cracks and notches is secured. Surfaces and edges to be welded shall be prepared in accordance with Section 3 of AWS D1.1/D1.1M. Chipping

and/or grinding will not be required except where specified and as necessary to remove slag and sharp edges of technically guided or hand-guided cuts not exposed to view. Visible or exposed hand-guided cuts shall be chipped, ground, or machined to metal free of voids, discontinuities, and foreign materials.

2.1.4 Alignment of Wetted Surfaces

Exercise care to ensure that the correct alignment of wetted surfaces being joined by a flanged joint is being obtained. Where plates of the water passage change thickness, a transition shall occur on the outer surface, leaving the inner surface properly aligned. When welding has been completed and welds have been cleaned, but prior to stress relieving, joining of plates shall be carefully checked in the presence of a Government inspector for misalignment of adjoining parts.

2.2 SUBMERSIBLE PUMP

2.2.1 Design and Manufacture

At the Contractor's option, the submersible pump may be either of cast or fabricated construction. The level of manufacture skill shall be consistent with the standards referenced in the specifications. All work performed in the manufacture of the pumps shall be performed in a skillful and workmanlike manner in accordance with the best modern shop practice and manufacture of finished products similar in nature to those specified herein. The Government reserves the right to observe and witness the manufacture of the pumps and to inspect the pumps for compliance with contract requirements during factory assembly.

2.2.2 Speed

2.2.2.1 Pump Speed

Rotative speed of the pump shall not be greater than 1200 rpm.

2.2.2.2 Runaway Speed

The pump shall be designed to sustain full runaway speed without damage at maximum head difference across the pump. Based on the system design as shown by the drawings the manufacturer shall compute the maximum reverse runaway speed, and the pump and motor shall be designed to sustain that reverse rotation without damage.

2.2.3 Pump Construction

2.2.3.1 General

The major pump components shall be of materials as described in Table 1. All the exposed nuts and bolts shall be stainless steel. All mating surfaces where watertight sealing is required shall be machined and fitted with nitrile rubber O-rings. The fitting shall be such that the sealing is accomplished by metal-metal contact between machined surfaces which results in controlled compression of the O-rings. Sealing compounds, grease, or secondary devices are not acceptable.

2.2.3.2 Pump Lifting Handle And Lifting Lugs

The lifting handle shall be designed to bear the entire weight of the

pumping unit at a conservative factor of safety. Lifting lugs shall be provided where the weight of the separate part requires a lug. The contractor shall follow the manufacturers recommendations for handling of the pump.

2.2.3.3 Pump and Motor Bearing Arrangement

The pump and motor bearings shall be the standard design of the manufacturer for the pump supplied under this specification. The type and number shall be of proven design as used in previous operating units supplied by the manufacturer. The bearings shall be of the grease lubricated and sealed type. The bearings shall have a minimum B-10 bearing life of 50,000 hr. Each bearing shall be of the correct design to resist the radial and thrust loads applied. Enough bearings shall be provided to ensure the pump rotating elements are supported so that the possibility of excessive vibration is eliminated. Ball and roller bearings life and load ratings shall conform to ABMA 9 and ABMA 11.

2.2.3.4 Mechanical Seals

A mechanical rotating shaft seal system shall be provided between the impeller and motor to ensure the motor housing seal. The mechanical seals shall be in tandem, lapped and face type seals running in lubricant reservoirs for cooling and lubrication. The mechanical seals shall contain both stationary and rotating tungsten carbide face rings unless otherwise specified. In order to avoid seal failure from sticking, clogging, and misalignment from elements contained in the mixed media, only the seal faces of the outer seal assembly and its retaining clips shall be exposed to the mixed media. All other components shall be contained in the lubricant housing. All seal faces must be solid material capable of being relapped. The seals shall require neither maintenance nor adjustment, but shall be easy to check and replace. Shaft seals without positively driven rotating members shall not be considered acceptable or equal.

2.2.3.5 Lubricant Housing

An oil housing shall be provided with oil, as recommended by the pump manufacturer, to lubricate the shaft sealing system and to dissipate the heat generated by the motor and bearings.

2.2.3.6 Impeller

The impeller design and manufacture shall be the manufacturer's standard. The impeller surface shall be smooth, without holes and fabrication offsets. The attachments to shaft shall be with keys or other fasteners which are to be made of stainless steel. The attachment should be of sturdy construction designed to not loosen, but be easily removed for maintenance. The impeller construction may be cast or fabricated. At the time of assembly the impeller clearances shall be those shown on assembly drawings and may be checked in the field or at the factory at the Contracting Officer's option. The impeller shall be balanced at the design operating speed. The standard balance quality grade is G6.3 in accordance with ANSI S2.19. Balancing procedure shall be in accordance with HI 9.6.4, except that a two-plane balance shall be required.

2.2.3.7 Shaft

The shaft shall be one piece integral with the motor of high-strength cold-rolled carbon steel or stainless steel with a factor of safety of five

measured against the ultimate strength. The shaft shall be designed for all torque conditions during normal operation and for runaway speed during reverse flow.

2.2.3.8 Bowl Assembly

The bowl assembly may be of cast or fabricated manufacture. The hydraulic design shall be the manufacturer's standard design as used in previous operating installations. The general manufacture quality relating to flange design, drilling, bolts, alignments, etc., shall be in accordance with industry standard practice.

2.2.4 Motor

The motor shall be submersible and conform to the requirements of NEMA MG 1. The motor shall be sized to avoid overload when operating at any point along the characteristic curve of the pump. The motors shall be 3-phase, 60-Hz, 460 V, squirrel cage induction type, NEMA Design B Type. The stator windings and stator leads shall be insulated with a moisture-resistant Class F insulation with temperature resistance of311 degrees F. The rated horsepower of the motor shall be not less than 110 percent of the determined maximum load requirement of the pump. The service factor shall be 1.15. The temperature rise above ambient for continuous full load rated conditions and for the class of insulation used shall not exceed the values in NEMA MG 1. The motor shall be rated for continuous duty when submerged and shall also be capable of operation in the dry for short periods of time for testing and maintenance purposes.

2.2.4.1 Torque

Starting torque shall be sufficient to start the pump, but in no case less than 60 percent of full-load torque. Break-down torque shall not be less than 150 percent of full-load torque.

2.2.4.2 Support

Thrust bearing support shall have sufficient strength and rigidity to support the weight of the entire rotating element of the motor, pump impeller and shaft, and the hydraulic thrust.

2.2.4.3 Power Factor and Efficiency

The power factor and efficiency at full load, ¾ full load, and ½ full load shall not be less than 80%, 65%, 55% and 90%, 89%, and 88% respectively. Motors will be rejected if factory tests specified in section 2.2.4.6 do not demonstrate that these values will be met or exceeded. Power factor correction shall be provided as required. Capacitors shall be located in the Control Building. Contactors and associated relays shall be provided within the motor starter cubicle for interfacing with the required capacitors.

2.2.4.4 Thermal Protection

A positive temperature coefficient thermistors (one per phase) shall be embedded in the windings. The thermistors, with required necessary equipment, shall open a normally-closed contact when the critical temperature is reached. All outgoing wiring shall terminate on the pump monitor panel, which shall be provided.

2.2.4.5 Motors, Motor Circuits, and Controllers

Motors shall be compatible with the requirements of American National Standard, NFPA 70 National Electrical Code, and installed in accordance with the requirements of Section C-16415 of these specifications.

2.2.4.6 Test Reports

Test reports in six copies recording all data obtained during above tests, shall be furnished to the Contracting Officer for each motor used.

2.2.5 Cable

Power and instrumentation cable shall be specifically designed for use with a submersible pump application and shall conform to the requirements of NEMA WC 7. Submersible cable shall be suitable for continuous immersion in water at the maximum depth encountered. Cable shall have an ampacity of not less than 125 percent of the motor full load current. The cable length shall be determined by the pump manufacturer for the installation shown but shall not be less than 30 ft.

2.2.5.1 Cable Entry

Power and instrumentation cables shall enter the motor through a sealing system that prevents water entry into the unit and provides strain relief. The cable entry may be comprised of rubber bushings, flanked by stainless steel washers, having a close tolerance fit against the cable outside diameter and the entry inside diameter for sealing by compression of the bushing, or the entry may be sealed by other gland compression methods.

2.2.6 Pump Control and Monitoring

A self-contained pump control and monitoring system shall be provided. Pump controls and control panels shall be provided in accordance with Section 16415. Independent local indication of the alarm and separate contacts for the remote indication of each alarm and local reset shall be provided. Sensors shall alarm and shut down the pump at an abnormal operating condition. Separate red alarm indicator lamps and green pump running lamps shall be provided and labeled in the enclosure specified in Section 16415. The following sensors shall be provided:

a. Temperature sensors in the stator windings to protect the motor against overheating.

b. Float-switch sensor positioned between the bearings and the stator-end coils to detect if liquid penetrates the stator housing.

2.2.7 Air Vent

An air vent shall be provided, located as shown on the contract drawings and shall be Golden Anderson Model 930 or approved equal. The valve shall be a minimum 125 lb class and sized for the design flow rate. An isolation valve shall be provided at the valve's inlet. Materials of construction shall be cast iron for the valve body; stainless steel for the internal linkage, float, and float stem; and Buna-N for the needle and seat. The valve shall provide a dual function to release air during pump start-up and to permit air to re-enter to break the vacuum during pump shutdown. Provide 2-inch drain piping for each vent as indicated on the contract drawings. Slope drain piping away from pump discharge tube to the wet well

discharge chamber. Contractor shall provide required amount of unions to disassemble the vent drain piping without destruction to piping so that pump discharge tube lid can be opened for pump inspection or removal. Air vent drain piping shall be schedule 80 PVC (gray color) to prevent deterioration of piping from sunlight. If required by manufacturer paint PVC piping as required to prevent sunlight damage.

2.3 DISCHARGE TUBE AND DISCHARGE ELBOW

2.3.1 General

The design, manufacture and installation of the discharge tube and discharge elbow shall be in accordance with the pump manufacturer's instructions. For purposes of performance and this specification it shall be treated as part of the pumping unit. The discharge tube shall be of such size to accommodate the dimensions of the pump supplied in accordance with the manufacturer's requirements. It shall be permanently installed in the pump sump as shown on the drawings. The design shall be such that the pumps will be automatically and firmly connected to the discharge tube when lowered into place and shall be in accordance with the pump manufacturer's instructions. A locking device shall be provided that prohibits rotational movement of the pump within the tube. The pumps shall be easily removable for inspection or service without need to enter the pump sump. The pumps shall not require any bolts, nuts, or fasteners for connection to the discharge housing. Stiffening, guides, or other features shall be provided at the pump support to ensure concentric positioning of the pump in the discharge tube. Means shall be provided such that an effective seal is obtained between the pump and discharge tube. Power cable penetrations shall be watertight.

A sole plate, as shown on the drawings, shall be installed.

2.3.2 Flanged Joints

Design flanged joints to be airtight and watertight, without the use of preformed gaskets, except that the use of a gasketing compound will be permitted. Mating flanges shall be male/female rabbet type or doweled with not less than four tapered dowels equally spaced around the flange. Flanges and drill bolt holes shall be machined concentric with the centerline, having a tolerance of plus or minus 1/4 of the clearance between the bolt and the bolt hole. When fabricated from steel plate, flanges shall not be less than 1-1/2 in. thick after machining. Flange machining shall not vary more than 10 percent of the greatest flange thickness. Fabricated flanges, as a minimum, shall be constructed to the dimensions of AWWA C207, Class B. Flanges shall be connected to the column tube with two continuous fillet welds, one at the inside diameter of flange-to-pump-tube and the other at the outside diameter of pump-tube-to-flange. Weld design is the pump manufacturer's responsibility. Mating flanges shall be machined parallel to a tolerance of 0.002 in. The machine mating flange surface shall be finished to 125 microns or better.

2.3.3 Nuts and Bolts

Nuts and bolts shall be of the hexagonal type. Bolts, including assembly, anchor, harness, and dowels, shall be 300 stainless steel. Nuts shall be bronze; washers shall be 300 series stainless steel.

2.3.4 Bolted Lid

A watertight lid shall be provided, hinged and bolted to the top of the discharge tube as indicated on the contract drawings. Bolted lid shall also have at the hinge a 120 degree stop on each side of the hinges to prevent the lidding from falling all the way over past 180 degrees when opened.

2.3.5 Flexible Coupling

Flexible mechanical coupling shall be provided connecting the pumping unit discharge tee/elbow to the wall thimble and the discharge piping similar to Straub Flex-2 coupling or approved equal. The middle ring shall be finished without pipe stop to facilitate the installation and removal of coupling.

2.3.6 Wall Thimble

The wall thimble shall have two plain ends to accommodate flexible mechanical coupling and the other to match the "F" Thimble provided to mate with the flap gate. The plain ends shall match the discharge elbow in thickness and diameter, and the other shall match the "F" Thimble. An anchor ring will be provided on the wall thimble, located so that it is centered in the wall when embedded, see mechanical drawing for detail of anchor ring. The wall thimble shall be fabricated from steel plates in accordance with ASTM A 36 and painted in accordance with paragraph 2.5 below.

2.3.7 Dissimilar Metals

When dissimilar metals are used in intimate contact, suitable protection against galvanic corrosion shall be applied. The anodic member shall be protected by proper electrical insulation of the joint.

2.4 INTAKE DESIGN

2.4.1 General

The intake sump design is the Contracting Officer's responsibility. It is the responsibility of the contractor to supply a pump that will meet the performance requirements without undue modifications to the sump as shown on the drawings. Any such modifications shall be at no cost to the Government and must receive prior approval.

2.5 PAINTING

The pump/motor shall be painted in accordance with the pump manufacturer's standard coating system. The painting of the discharge tube and discharge elbow and appurtenances shall be in accordance with Section 09964 PAINTING: HYDRAULIC STRUCTURES.

2.6 SPARE PARTS

The Contractor shall furnish the following spare parts:

a. One complete set of bearings and seals.

b. Replacement wearing rings and O-rings.

2.7 SHOP ASSEMBLY

The discharge tube and discharge elbow shall be assembled in the manufacturer's plant to ensure the proper fitting and alignment of all parts. Prior to disassembly, all parts shall be match-marked to facilitate the correct assembly in the field.

2.8 NAMEPLATE

The pumping unit shall be identified by means of a separate nameplate permanently affixed in a conspicuous location. The plate shall bear the manufacturer's name, model designation, serial number if applicable, and other pertinent information such as horsepower, speed, capacity, type, and direction of rotation. The plate shall be made of corrosion-resistant metal with raised or depressed lettering and a contrasting background.

2.9 INSTRUCTION PLATES

The pumping unit shall be equipped with suitably located instruction plates, including any warnings and cautions, describing any special and important procedures to be followed in starting, operating, and servicing the equipment. Plates shall be made of corrosion-resistant metal with raised or depressed lettering and a contrasting background.

2.10 FACTORY TEST

2.10.1 Performance Test

The pump shall be tested at the manufacturer's shop to demonstrate that the proposed pump operates without instability and complies with specified performance. Instability is defined when any point in usable range of the head-capacity curve cannot be repeated within 3 percent. When this occurs, the test shall be rerun. Compliance with specifications will be determined from curves required by the paragraph TEST RESULTS. Test procedures, except as herein specified, shall be in accordance with applicable provisions of HI 2.6. The temperature of the water used for testing shall be approximately the same for all tests run and shall be recorded during test runs.

2.10.1.1 Performance of the Pump

Performance of the pump shall be determined by a series of test points sufficient in number to develop a constant speed curve over the range of total heads corresponding to the requirements of the paragraph CAPACITIES. The test range shall include additional testing at total heads of 2 ft higher than that specified. The lowest total head for testing shall be, as a minimum, the total head determined from the referenced paragraph. If the test setup permits testing at lower total heads, the range of total heads shall be extended 2 ft lower. Testing shall be inclusive for the speed involved. Tests shall be made using heads and a suction water elevation specified in the paragraph CAPACITIES. Test results with this sump elevation shall meet all specified conditions of capacity, head, andbhp. Head differentials between adjacent test points shall not exceed 3 ft, but in no case shall less than 10 points be plotted in the pumping range. If the plot of data indicates a possibility of instability or a dip in the head-capacity curve, a sufficient number of additional points on each side of the instability shall be made to clearly define the head-capacity characteristics.

2.10.1.2 Test Results

Test results shall be plotted to show the total head, static heads, bhp, and efficiency as ordinates. The results should be plotted against pump discharge in gpm as the abscissa. Curves shall be plotted showing pump performance to a scale that will permit reading the head directly to 0.5 ft, capacity to 200 gpm, efficiency to 1 percent, and power input to 5 bhp. It shall be established that the performance requirements of these specifications and the warranties under this contract have been fulfilled. The performance test shall be made with the pump and motor assembled as an operating unit to simulate field installation unless otherwise approved in writing by the Contracting Officer. Readings shall include one point each within 2 percent of the rated total head, minimum expected head, and maximum expected head. The test shall be conducted in accordance with accepted practices at full speed; and, unless otherwise specified, the procedure and instruments used shall conform to HI 2.6.

2.10.2 Instrumentation and Procedures

Each instrument shall be described in detail, giving all data applicable, such as manufacturer's name, type, model number, certified accuracy, coefficient, ratios, specific gravity of manometer fluid to be used, and smallest scale division. When necessary for clarity, a sketch of the instrument or instrument arrangement shall be included. A fully detailed narrative description of each proposed method of instrumentation, procedures to be used, and a sample set of computation shall be included. The lowest equivalent static head that is obtainable with the testing when operating along the head-capacity curve of the proposed pump shall be stated.

2.10.2.1 Head Measurements

Head measurements shall be made using either a direct reading water column, mercury-air, mercury-water, a Meriam fluid manometer, or a pressure transducer. Vacuums shall be measured with either a mercury-air manometer, a mercury-water manometer, or a pressure transducer. Fluctuations shall be dampened sufficiently to permit column gauges or a differential pressure transducer to be read to either the closest one one-hundredth (0.01) of 1 ft of water or Meriam fluid or one-tenth (0.1) of 1 in. of mercury.

Manometers shall be used as indicated by ISA RP2.1. When pressure transducers are used, their accuracy shall be checked with a manometer.

2.10.2.2 Pump Capacity

Capacity shall be determined by a calibrated venturi flowmeter or a long-radius ASME flow nozzle. Orifice plates shall not be used. Venturi or nozzle taps shall be connected to column gauges equipped with dampening devices that will permit the differential head to be determined to either the closest one-hundredth (0.01) of 1 ft or water or one-tenth (0.1) of 1 in. of mercury. Magnetic flowmeters and flowmeters utilizing ultrasonic flow measurements will be acceptable if the calibration of the flowmeter has been completed within the last 6 months.

2.10.2.3 Rotational Speed of Pump

Rotational speed of the pump shall be measured in accordance with measurement of speed in HI 2.6, except that revolution counters shall not be used. The device used shall permit the speed to be determined to 1 rpm.

2.10.2.4 Power Input

Power input to the pump shall be measured in accordance with power measurements in HI 2.6. A method to permit bhp to be determined to the closest 0.5 bhp shall be used.

2.10.3 Factory Test Report

Each factory test report shall include, as a minimum, the following:

a. Statement of the purpose of test, name of project, contract number, and design conditions. Instances where guaranteed values differ from specified values should be given.

b. Resume of preliminary studies, if such studies were made.

c. Description of pump and motor, including serial numbers, if available.

d. Description of test procedure used, including dates, test personnel, any retest events, and witness test data.

e. List of all test instruments with model numbers and serial numbers.

f. Sample computations (complete).

g. A discussion of test results.

h. Conclusions.

i. Photographic evidence in the form of either 24 color photographs of test equipment, test setup and representative test segments, or a VHS videotape, at least 30 minutes in length, covering the same information as photographs. All photographic evidence should be labeled with contract number, location, date/time, and test activity. Videotape shall be voice annotated with the same information.

j. Copies of instrument calibration.

k. Copies of all recorded test data.

l. Curves required by the paragraph TESTS RESULTS.

m. Curves showing the performance of the prototype pump.

n. Drawings of the test set-up showing all pertinent dimensions, elevations and cross section of the pump.

PART 3 EXECUTION

3.1 INSTALLATION

Correct installation and assembly of the pumping unit shall be the Contractor's responsibility and shall be in accordance with the drawings and with the manufacturer's installation instruction manual. The Contractor shall furnish all bolts, shims, tools, and other devices necessary for installing the pumping units. The manufacturer's representative(s) familiar with the equipment being installed shall supervise the handling, installation, start-up, and testing of the equipment as required in the paragraph INSTALLATION AND START-UP ENGINEER.

3.2 CLEANUP PRIOR TO START

After the pumping unit is installed and prior to start-up, complete clean up of the sump area of any accumulated construction debris shall be done. This final cleaning of the sump area will be witnessed by a representative of the Government. Any damage to the pumping units or related equipment during initial start-up due to foreign objects left in the sump areas shall be corrected at the Contractor's expense.

3.3 PUMP FIELD TESTS

Field testing shall be conducted by an experienced field test engineer and will be witnessed by the Contracting Officer. Before initially energizing the pump/motors, the Contractor shall have successfully tested all pumping plant control, monitoring, and protective circuits. This thorough electrical checkout procedure shall have followed a detailed step-by-step approved test plan. The motor and other pumping unit elements undergoing tests should also be checked at this time.

3.3.1 Dry Test

Each pumping unit shall be tested in the dry in accordance with the pump manufacturer's instructions to determine whether it has been properly installed. Such tests shall be made when, and as, directed by the Contracting Officer. The pump shall be operated at full rated speed. Should tests reveal a design or installation deficiency or a manufacturing error in pumping unit components, the problem shall be promptly corrected by and at the expense of the Contractor.

3.3.2 Wet Test

Each unit shall be given an operating test under load for a period of at least 1 hr or as directed by the Contracting Officer. The tests shall be conducted by the Contractor and will be witnessed by the Government. During the tests, the operation of the pumping units shall be observed and measurement of noise (in accordance with HI 9.1-9.5), motor-bearing temperatures, voltage, and current shall be recorded for each pump. Measured parameters shall be within the pump manufacturers published limits. Vibration measurements shall be made at the top of the discharge tube for each pump. Vibration limits shall not exceed those recommended by HI 9.6.4. Without additional cost to the Government, the Contractor shall make all changes and correct any errors for which the Contractor is responsible.

3.3.3 Field Test Report

A test report of the field testing and a manual of Operating and Maintenance Instructions for the completed system shall be prepared and submitted in accordance with paragraph SUBMITTALS.

FIGURE 1

SYSTEM HEAD LOSS TABLE

FLOW (GPM)	SYSTEM LOSS (SEE NOTE 1, FEET OF WATER)
2,200	1.3
2,400	1.5
2,600	1.8
2,800	2.0
3,000	2.3

NOTE 1: System head loss table includes velocity head, pipe and fittings from 24-inch pump discharge tube intake including a 12-inch tee thru the sump wall to the wet well to the 12-inch discharge flap gate Losses thru the wet well and large discharge pipe to the river are negligeble due to the size of the well and piping.

-- End of Section --